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(54) Title: DEVICE FOR FORMING ELECTRICAL CONNECTIONS (57) Abstract <p>An electrical connecting device comprises two conical connecting elements, each of which is arranged to receive a respective conductor of a coaxial cable for example. At least one of the connecting elements is provided with a ring of solder, and the elements are enclosed within a heat-shrinkable sleeve. A termination member extends from each of the connecting elements to the exterior of the sleeve for connection for example to a printed circuit board.</p> <div data-bbox="933 1150 1550 1564"></div>		

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DEVICE FOR FORMING ELECTRICAL CONNECTIONS

This invention relates to a device for forming electrical connections, particularly between electrical wires or cables and circuit boards.

Many methods are known for terminating wires and cables and connecting them to other objects such as printed circuit boards. Some of the most successful methods in terms of reliability of termination, environmental sealing and ease of termination involve the use of solder inside a heat-recoverable sleeve. For example, United States Patent No. 4060887 (B010) describes a connector comprising two heat-recoverable sleeves, each of which contains a solder insert, each sleeve also having a pin extending therefrom for connection to a pcb for example. The pins are arranged to terminate respectively the inner conductor and outer screen of a coaxial cable and the solder inserts are arranged to provide soldered connections between each pin and the cable. A similar type of device is disclosed in European Patent Application No. 0306343 (FP043), in which the pins have a region of non-uniform cross-section, which increases the force required to pull the pins out of the device.

International Patent Application No. WO 93/21669 (FP074) describes a device which is similar to that disclosed in US 4060887 but which has a unitary sleeve and both pins extend out of the same end of the sleeve. At least one of the pins is electrically insulated in order to prevent a short circuit between the pins. This device has the advantage that its manufacturing process is relatively simple since only one sleeve, rather than two, is employed and the relatively difficult requirement of locating one sleeve within another is removed.

Simple electrical connectors which contain a screw thread are well known and are commonly used for connecting together a bundle of wires by screwing the bundle into the connector. In addition, more sophisticated connectors are known, such as for example the connectors described in International Patent Application No. WO 92/00616 (FP057). These connectors contain, in addition to a screw thread connector, a quantity of solder which provides a permanent soldered connection once the connector has been heated for a sufficient period of time for the solder to melt. The screw thread connector may be formed from a tapering coil of metal wire, preferably of polygonal cross-section. The connectors are environmentally sealed by means of a heat-recoverable sleeve which may

additionally contain thermoplastic sealing rings.

International Patent Application No. WO 93/05546 (FP066) describes an electrical terminal which includes a terminal portion comprising a lug portion and a hollow shank. The terminal has a tapering hollow connection piece that has internal and external screw threads, part of the connection piece being located within the shank of the terminal portion. The connection piece may comprise a metal wire wound into a tapering helix.

International Patent Application No. WO 93/11584 (FP069) describes an electrical connector that may be used to form a connection between the screen of a coaxial cable and one or more wires for example. The connector contains a connecting element having a tapering internal surface that has a screw thread, and this may be formed from a tapering coil of metal wire.

International Patent Application No. WO 93/16503 (FP073) describes a termination arrangement for a coaxial cable, comprising a heat-recoverable sleeve containing a connecting element for the cable screen, the connecting element having a generally cylindrical portion whose diameter is capable of changing and which is held in a state of relatively large diameter by a quantity of solder and/or the sleeve, the element changing to a state of relatively small diameter when the sleeve is recovered. The connecting element may be in the form of a helicoidal spring.

In accordance with the present invention, there is provided a device for forming an electrical connection between at least one elongate electrical conductor and an object, which comprises (a) an insulating cover; (b) a first connecting element located inside the cover; (c) a first elongate electrically conductive termination member pre-installed in the cover, wherein the first connecting element has a tapering internal surface that is arranged to allow part of the at least one elongate electrical conductor to be inserted therein, and the elongate electrically conductive termination member extends from the inside of the cover to the outside of the cover and is arranged to form an electrical connection between the at least one elongate electrical conductor and the object; and (d) a second connecting element longitudinally spaced apart from the first connecting element, which is arranged to allow part of at least one further elongate conductor to be inserted therein and which is provided with a second

elongate conductive termination member which is arranged to form an electrical connection between the at least one further elongate electrical conductor and the or a further object.

The invention has the advantage that elongate electrical conductors, e.g. wires or cables, may normally be terminated quickly and reliably by inserting the wire or cable into the connecting element of the device. The screw thread provided on the tapering internal surface of the connecting element normally grips the wire, especially if the wire or cable is twisted or screwed into the connecting element. The elongate conductive member extending from the inside to the outside of the cover may be conveniently connected to another object, for example a terminal or an electrical connector, but preferably a circuit board, e.g. a printed circuit board or an electrical or electronic component.

The connecting device of the invention has the advantage that two elongate conductors may be terminated by means of a single device. This is particularly advantageous for terminating coaxial cables. For example, the first connecting element may be used to terminate the inner conductor(s) of a coaxial cable and the second connecting element may be used to terminate the screen or outer conductor (e.g. braid) of the coaxial cable. Accordingly it is preferred that the at least one elongate electrical conductor comprises the central conductor or conductors of a coaxial cable and at least one further elongate electrical conductor comprises the screen of the coaxial cable.

According to a particularly preferred embodiment the second connecting element has a tapering internal surface that is provided with a screw thread.

The expression 'screw thread' used herein should be construed broadly as including substantially any screw-thread-like profile provided on the tapering internal surface of the or each connecting element, e.g. one or more continuous or discontinuous helical ridges and/or furrows. According to especially preferred embodiments of the invention, the or each connecting element comprises a tapering coil of wire and the or each screw thread is formed from the profile of the wire inside the coil. The wire may generally have any cross-section, including a circular or an oval cross-section. Preferably, however, the cross-section of the wire is such that the wire has a longitudinal ridge which is arranged to form the screw thread inside the coil. Most preferably the wire has a

polygonal cross-section, and in this case at least one of the angled portions of the cross-section may form the ridge extending along the length of the wire.

Embodiments of the invention in which the or each connecting element comprises a tapering coil of wire have the advantage that elongate electrical conductors inserted into the or each connecting element are normally gripped by the coils. This may, for example, be due to resilient deformation, radial and/or axial, of the coil upon insertion of the or each elongate electrical conductor therein. Alternatively or additionally, if the wire of the coil is provided with a longitudinal ridge, the ridge may dig into the or each elongate conductor.

The connecting elements of the device according to the invention may be formed from any of a variety of materials, for example from plastics materials. Preferably, however, the connecting element, especially when it is in the form of a wire, is formed from metal, for example a substantially pure metal or a metal alloy. Preferred metals are steel, especially spring temper steel or ferritic stainless steel, and copper, or alloys of copper, especially hard temper copper. It is to be understood that the term 'wire' as used herein includes wire formed from non-metallic, e.g. plastics, materials as well as from metallic materials.

The or each elongate conductive termination member that is pre-installed in the cover is preferably substantially rigid. For example the termination members preferably comprise a pin or similar connection member that may be connected to an electrical or electronic component or a circuit board, e.g. a printed circuit board. The termination members may be distinct from the or each connecting element. In this case the or each elongate termination member may be pre-installed in the device by being bonded or fixed to or mounted on the cover and/or the or each connecting element. For example the termination members may be fixed in position by being press-fit or screwed into the connecting element. In the latter case the termination member may, for example, be provided with a screw thread or a serration along at least part of its length for this purpose. Alternatively the or each termination member may comprise part of its respective connecting element, e.g. the termination members may advantageously comprise part of the wire of the connecting element when the connecting element is formed from a wire coil. This has the advantage of reducing the number of discrete parts required to manufacture a device according to the invention, and it also ensures good electrical contact between

the or each connecting element and its respective termination member.

The or each elongate conductive termination member is preferably formed from metal, for example a substantially pure metal or a metal alloy. Preferred metals are steel, especially spring temper steel, and copper, especially hard temper copper.

In embodiments according to the invention which comprise a first connecting element and a second connecting element longitudinally spaced apart from the first connecting element, the two connecting elements may be located inside different covers or, preferably, they may be located inside the same cover.

The first and second elongate termination members may conveniently comprise a single part which connects the first and second connecting elements outside the cover(s). For example, when the connecting elements are formed from coiled wire and the termination members comprise part of the wire of the connecting elements, the first and second connecting elements and the first and second termination members may all be formed from a single piece of wire. Then, either in use or as part of the manufacturing process the connecting portion of wire etc between the two termination members may be removed so that the two connecting elements are no longer connected.

According to a preferred embodiment of the invention the device further comprises at least one quantity of solder located inside the cover. This has the advantage that an initial termination of an elongate electrical conductor may be carried out merely by inserting it into the connecting element of a device according to the invention so that, for example, the integrity of the termination may be tested before a final solder connection is formed by heating the device to cause the quantity of solder to melt. A solder connection has the advantages of strength and permanence and a solder connection formed by means of a device according to the invention normally has a relatively low contact resistance and may often be used in relatively high current (e.g. 45 Amperes) applications.

The solder may normally be located anywhere inside the insulating cover where it will be able to flow into the connecting element to form a solder joint therein and where it will not substantially hinder insertion of elongate conductors into the connecting element. The solder may have any of a number of

different shapes, for example it may be in the form of a pellet or a ball, but preferably it is in the form of a ring, and more preferably each solder ring is located around the or one of the connecting elements. In a particularly preferred embodiment of the invention, the or each quantity of solder comprises a strip of solder that has been wrapped into the shape of a ring so that one portion of the strip overlaps another portion.

The solder may be formed from any one or more appropriate solder compositions. For example it may be formed from an $\text{Sn}_{63}\text{Pb}_{37}$ eutectic composition which will melt as the device is heated. Alternatively, the solder preform may comprise a composite having a portion that is formed from a relatively high melting point solder, as described in International Publication No. WO 88/09068. In this form of device, melting of the higher melting point component e.g. $\text{Sn}_{96.5}\text{Ag}_{3.5}$ eutectic will normally provide a visual indication that the device has been heated sufficiently to melt the lower melting point component and to form a satisfactory solder joint. If desired, the lower melting point component may be of non-eutectic composition and, for example as described in International Publication No. WO 90/09255, the higher and lower melting point components may together form a eutectic composition. For example, a non-eutectic $\text{Sn}_{60}\text{Pb}_{40}$ lower melting point component may be employed with a higher melting point component formed from pure tin in relative amounts such that an $\text{Sn}_{63}\text{Pb}_{37}$ eutectic is formed. The disclosures of these two patent applications are incorporated herein by reference. An advantage of employing a two component solder, and especially a tin, $\text{Sn}_{60}\text{Pb}_{40}$ combination is that it reduces the possibility of 'wicking', that is to say, travel of the solder away from the joint area due to capillary action, which can be caused by prolonged heating of the device.

According to a particularly preferred embodiment of the invention the insulating cover is dimensionally heat-recoverable. Dimensionally heat-recoverable articles are well-known and comprise articles which have a dimensional configuration which may be made substantially to change when subjected to heat treatment. Usually, such articles recover, on heating, towards an original shape from which they have previously been deformed, but the term 'heat-recoverable', as used herein, also includes articles which, on heating, adopt a new configuration, even if they have not previously been deformed.

The heat-recoverable cover may comprise a heat shrinkable sleeve made from a polymeric material exhibiting the property of elastic or plastic memory as described, for example, in US Patents 2027962, 3086242 and 3597372. As is made clear in, for example, US Patent 2027962, the originally dimensionally heat-stable form may be a transient form in a continuous process in which, for example, an extruded tube is expanded, whilst hot, to a dimensionally heat-unstable form but in other applications, a preformed dimensionally heat-stable article is deformed to a dimensionally heat-unstable form in a separate stage.

The insulating cover is preferably formed from a polymeric material. Preferred materials include: low, medium or high density polyethylene; ethylene copolymers, e.g. with alpha olefins such as 1-butene or 1-hexene, or vinyl acetate; polyamides, especially Nylon materials, e.g. Nylon 6, Nylon 6,6, Nylon 11 or Nylon 12; and fluoropolymers, e.g. polytetrafluoroethylene, polyvinylidene fluoride, ethylene-tetrafluoroethylene copolymer or vinylidene fluoride tetrafluoroethylene copolymer.

Preferably the device according to the invention includes at least one quantity of sealing material contained in the insulating cover, for sealing the device against moisture ingress. The sealing material may for example comprise gel or it may comprise fusible polymeric material.

The term "gel" as used herein is intended to mean a liquid-extended polymer composition. Such compositions normally contain a three-dimensional network of cross-linked molecular chains and preferably include at least 300 parts, more preferably at least 500 parts by weight of extender liquid per 100 parts by weight of the polymer composition. The gel used in the invention preferably has a cone penetration value (measured by ASTM D217) within the range of from 100 to 400 10^{-1} millimetres, more preferably 100 to 350 10^{-1} millimetres; an ultimate elongation (measured by ASTM D412) preferably greater than 100%, with substantially elastic deformation to an elongation of preferably at least 100%; and ultimate tensile strength (ASTM D412) preferably less than 1 MegaPascal.

The polymer composition may for example comprise an elastomer, or a block copolymer having relatively hard blocks and relatively elastomeric blocks. Examples of such copolymers include styrene-diene block copolymers, for

example styrene-butadiene or styrene-isoprene diblock or triblock copolymers as disclosed in International Patent Publication No. WO 88/00603. The extender liquids employed in the gel preferably comprise oils conventionally used to extend elastomeric materials. The oils may be hydrocarbon oils, for example paraffinic or naphthenic oils, synthetic oils for example polybutene or polypropene oils, and mixtures thereof. The preferred oils are mixtures of non-aromatic paraffins and naphthenic hydrocarbon oils. Suitable gels can also be prepared by curing reactive silicones with non-reactive extender silicones. The gel may contain known additives such as moisture scavengers (eg. benzoyl chloride), antioxidants, pigments and fungicides.

The fusible polymeric material according to the invention preferably comprises a hot-melt adhesive. The material may, for example, be formed from an olefin homopolymer or from a copolymer of an olefin with other olefins or ethylenically unsaturated monomers. Preferred examples include high, medium or low density polyethylene or ethylene copolymers with alpha olefins, especially C3 to C8 alpha olefins, vinyl acetate or ethyl acrylate. Alternatively, the material may be formed from polyamides, polyesters, halogenated polymers and the like. Preferred polyamides include those having an average of at least 15 carbon atoms between amide linkages, for example those based on dimer acids and/or dimer diamines. Examples of such adhesives are given in US Patents Nos. 4018733 to Lopez et al and 4181775 to Corke, the disclosures of which are incorporated herein by reference. Particularly preferred polyamides are those which are sold under the trade name "VERSALON" by General Mills Chemicals Inc. of Minneapolis, USA. Alternatively, the fusible polymeric material may comprise a thermoset material or composition. For example, the material may comprise one or more phenolic resins, amino resins, epoxy resins, or mixtures thereof, together with one or more curing agents, for example having reactive amine groups. It is preferred for the thermoset material to be in particulate form, for example as described in US Patent 4896904, the disclosure of which is incorporated herein by reference.

The at least one elongate electrical conductor may comprise the central conductor or conductors of a coaxial cable and the at least one further elongate electrical conductor may comprise the screen of the coaxial cable.

The or each object connected by the device of the invention may comprise

a circuit board, preferably a printed circuit board.

The invention will now be described by way of example with reference to the accompanying drawings, in which:

- Figure 1 shows a device that is not itself in accordance with the invention, but which is useful in illustrating the inventive principle;
- Figure 2 shows the device of Figure 1 with a wire terminated therein;
- Figure 3 shows a sealed form of the device of Figure 1;
- Figure 4 shows an alternative form of device that is not in itself in accordance with the invention, but which is useful in illustrating the inventive principle;
- Figure 5 shows a device for terminating the screen of a coaxial cable;
- Figure 6 shows the device of Figure 5 modified in accordance with the invention, with an additional connecting element for terminating the central wire of a coaxial cable;
- Figure 7 shows two connecting elements suitable for use with the invention, that are formed from a single piece of wire; and
- Figure 8 shows two connecting elements suitable for use with the invention, with a different arrangement of elongate termination members.

Figure 1 shows a device 1 comprising an insulating cover in the form of a heat-recoverable sleeve 3 containing a connecting element 5 and a quantity of solder 7 in the form of a ring located around the connecting element. A pre-installed elongate termination member in the form of a copper pin 9 extends from the inside of the sleeve to the outside of the sleeve and is secured in place by means of a front portion 11 of the sleeve having been recovered about the pin. The pin 9 is substantially straight, but a portion of an alternative form of pin 10 is shown: this pin has a right-angled bend in the portion located outside the sleeve. Right-angled pins are particularly suitable for connecting wires and the like to

circuit boards. The connecting element 5 is in the form of a tapering helical coil of copper wire. A wire 13 is shown prior to insertion into the device. The wire may be inserted into the relatively wide open end of the tapering coil of the connecting element which then grips the wire. The device may then be heated, for example by means of a hot air gun, or an infrared heater, e.g. a catalytic heater, to cause the sleeve to recover, i.e. shrink down over the connecting element and the end of the wire and to cause the solder to melt and flow between the windings of the coil and form a solder connection between the wire and the pin. The resulting fully completed termination is shown in Figure 2. Figure 3 shows another termination of a wire by means of a device containing fusible polymeric sealing material 17 which has melted and sealed the ends of the heat-recoverable sleeve 3.

Figure 4 shows a device that is similar to the devices shown in figures 1 to 3, but in this case the elongate termination member 19 comprises part of the wire of the connecting element extending out of the sleeve 3 beyond the relatively narrow end 21 of the connecting element.

Figure 5 shows a device 23 for terminating the screen of a coaxial cable and connecting it to a printed circuit board 25. A coaxial cable 27 which has lengths of its dielectric, screen and insulation stripped back is shown inserted into the device 23. The connecting element 29 in the form of a coil of copper grips the screen braid of the cable. The elongate termination member 31 is bent substantially at right angles to the axis of the cable so that the cable may be connected, via the device, to the printed circuit board in such a way that the cable is substantially parallel to the board. The elongate termination member 31, comprising an extension of the coil of the connecting element, may be inserted into the orifice 33 in the pcb and the solder 35 melted to form a solder connection.

Figure 6 shows the device 23 of Figure 5 with an additional connecting element 37 installed on the inner wire 39 of the coaxial cable. The elongate termination members 31 and 41 of the two connecting elements are arranged to be inserted into orifices 33 and 43 of the pcb 25, thereby terminating the coaxial cable and connecting it to the pcb.

Figure 7 shows two connecting elements comprising a single piece of copper that is wound into two longitudinally spaced apart tapering helical coils

that are joined by means of a substantially square U-shaped portion 43 of the wire. The legs 45 and 47 of the U-shaped portion comprise first and second elongate termination members and therefore the two elongate termination members comprise a single part which connects the two connecting elements. The portion 49 of wire joining the two termination members may be snipped off, either as part of the process of manufacturing the device or just prior to using the device.

Figure 8 shows two connecting elements that are similar to those shown in Figure 7, but in this instance the termination members 51 and 53 extend from the ends of the connecting elements that are furthest apart, as opposed to the ends closest together as in Figure 7.

It will be appreciated that the arrangement of connecting elements shown in Figures 7 and 8 will be enclosed within a sleeve, preferably a heat-recoverable sleeve, and may include solder, as discussed above with respect to the previous figures.

CLAIMS

1. A device for forming an electrical connection between at least one elongate electrical conductor and an object, which comprises (a) an insulating cover; (b) a first connecting element located inside the cover; (c) a first elongate electrically conductive termination member pre-installed in the cover, wherein the first connecting element has a tapering internal surface that is arranged to allow part of the at least one elongate electrical conductor to be inserted therein, and the elongate electrically conductive termination member extends from the inside of the cover to the outside of the cover and is arranged to form an electrical connection between the at least one elongate electrical conductor and the object; and (d) a second connecting element longitudinally spaced apart from the first connecting element, which is arranged to allow part of at least one further elongate conductor to be inserted therein and which is provided with a second elongate conductive termination member which is arranged to form an electrical connection between the at least one further elongate electrical conductor and the or a further object.
2. A device according to claim 1, wherein the first and/or second connecting element has a tapering internal surface that is provided with a screw thread.
3. A device according to claim 1 or claim 2, wherein the or each connecting element comprises a tapering coil of wire and the or each screw thread is formed from the profile of the wire inside the coil.
4. A device according to claim 3, wherein the wire is provided with a longitudinal ridge which is arranged to form the screw thread inside the coil.
5. A device according to any preceding claim wherein the or each elongate conductive termination member comprises part of its respective connecting element.
6. A device according to claim 3 or 4 wherein the or each elongate conductive termination member comprises part of the wire of the

connecting element.

7. A device according to any one of the preceding claims, wherein both the first connecting element and the second connecting element are located inside the cover.
8. A device according to any one of the preceding claims, wherein the first elongate conductive termination member and the second elongate conductive termination member comprise a single part which connects the first and second connecting elements outside the cover.
9. A device according to any one of the preceding claims which further comprises at least one quantity of solder located inside the cover, and wherein each quantity of solder is in the form of a ring located around one of the connecting elements.
10. A device according to any preceding claim, wherein at least part of the cover is dimensionally heat-recoverable.
11. A device according to any preceding claim, wherein the cover contains at least one quantity of sealing material for sealing the device against moisture ingress.

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Fig.1.

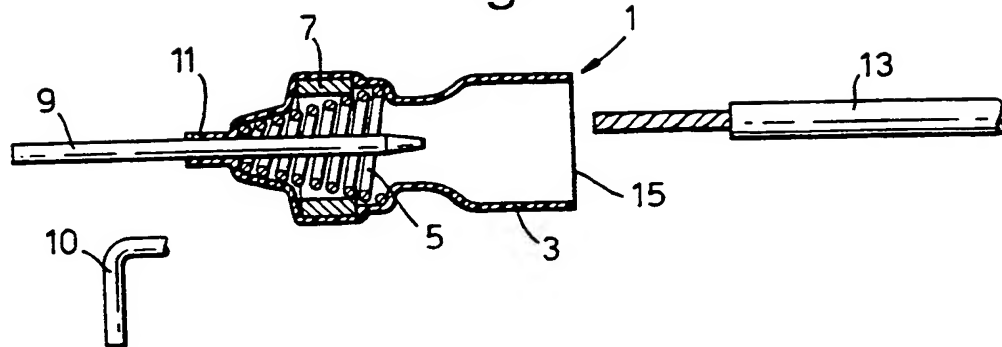


Fig.2.

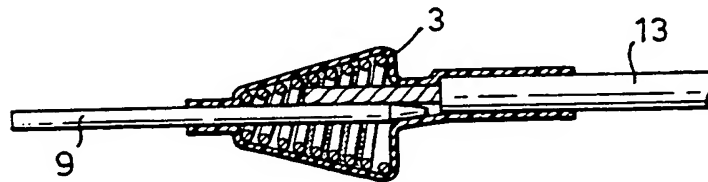


Fig.3.

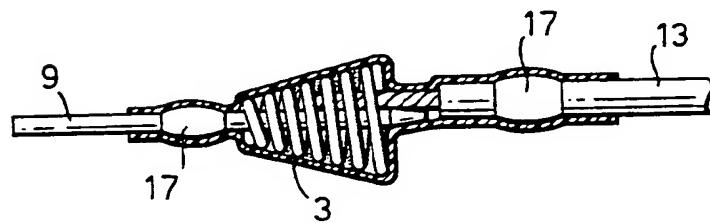
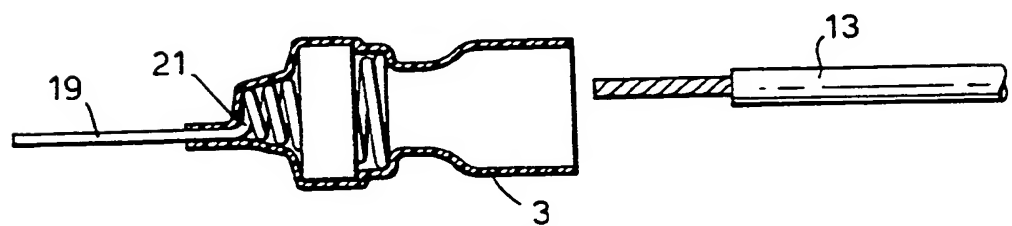


Fig.4.



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Fig.5.

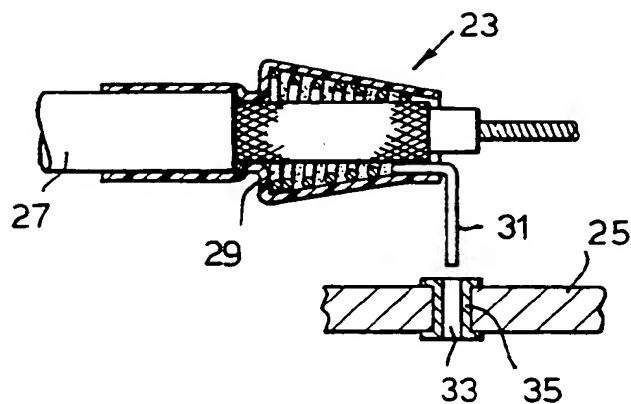


Fig.6.

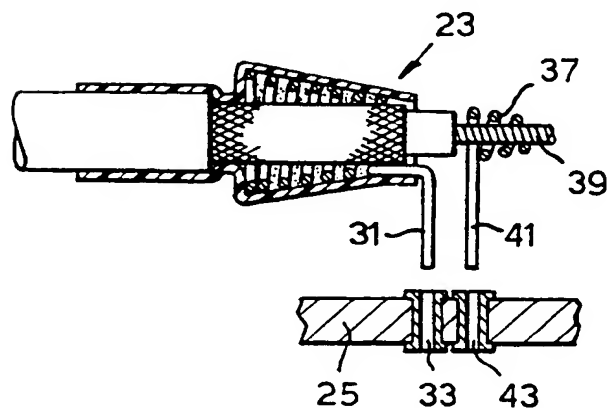


Fig.7.

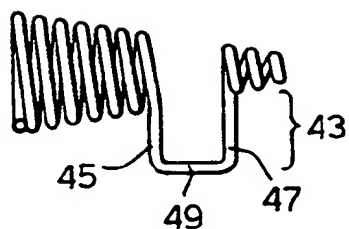
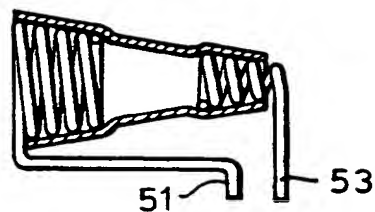


Fig.8.



INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 94/02764

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H01R9/05 H01R4/72 H01R4/48

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H01R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US,A,4 060 887 (DE GROEF) 6 December 1977 cited in the application see column 2, line 27 - column 9, line 60; figures 1-4	1
A	WO,A,93 11584 (RAYCHEM LIMITED) 10 June 1993 cited in the application see page 1 - page 9; figures 1-5	1
A	DE,B,11 35 538 (MINNESOTA MINING AND MANUFACTURING COMPANY) 30 August 1962 see column 1 - column 10; figures 1-14	1

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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